New Technology Screening Results for Army Tactical Equipment Maintenance Facilities (TEMF)

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TEMF Study Objective

Incorporate technologies to improve energy efficiency, indoor air quality, and occupant comfort/productivity into new standard TEMF now under design

TEMF Study Approach

- Review existing standard TEMF design
- Visit representative TEMF facilities
- Develop candidate technology options
  - Must improve facility performance
  - Must be cost-effective
  - Must be standard industry practice
- Evaluate options
- Participate in charrette/design process for new std TEMF
- Develop “final” recommendations
- Follow thru with G4, ACSIM and Corps folks

TEMF Study Approach

- ***Review existing standard TEMF design***
- **Visit representative TEMF facilities**
- **Develop candidate technology options**
  - **Must improve facility performance**
  - **Must be cost-effective**
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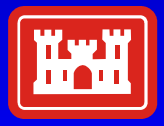

Existing TEMF Standard Design

- Seven prototype buildings
- Little specific envelope or mechanical guidance
- Ventilation system
  - Hose reel vehicle exhaust (Economy model)
  - Demand-controlled ventilation (4 Air Chgs/hr Min)

TEMF Study Approach

- Review existing standard TEMF design
- *Visit representative TEMF facilities*
  - *Site visits to Ft Drum, Ft Lewis, Detroit Arsenal, Ft Hood*
- Develop candidate technology options
- Evaluate options
- Participate in charrette/design process for new std TEMF
- Develop “final” recommendations
- Follow thru with G4, ACSIM and Corps folks

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P&H

TEMF Study Approach

- Review existing standard TEMF design
- Visit representative TEMF facilities
- ***Develop candidate technology options***
  - ***Must significantly improve facility performance***
  - ***Must be cost-effective***
  - ***Must be standard industry practice***
- Evaluate options
- Participate in charrette/design process for new std TEMF
- Develop “final” recommendations
- Follow thru with G4, ACSIM and Corps folks

Candidate TEMF Technologies

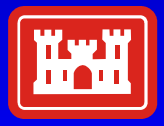
- Design IAW ASHRAE's new "Advanced Energy Design Guide: Small Office Buildings"
- Cool Roofs
- Effective Ventilation System
  - Improved Source Capture Vehicle Exhaust and Reduced Ventilation
  - Solar Wall to Preheat Make-up Air
- Radiant Floor Hydronic Heating
- Evaporative Cooling
- Vehicle Entry/Exit Vestibule(s)

Technology First Costs (New Const)

- Design IAW ASHRAE – minimal increase
- Cool Roofs - no additional cost
- Improved Vehicle Exhaust Capture and reduced ventilation - cheaper than current system
- Solar Wall – approx $10 per sq ft
- Radiant Floor Heat – no additional cost
- Evaporative Cooling – approx $2k/bay
- Vestibule – approx $20K ea

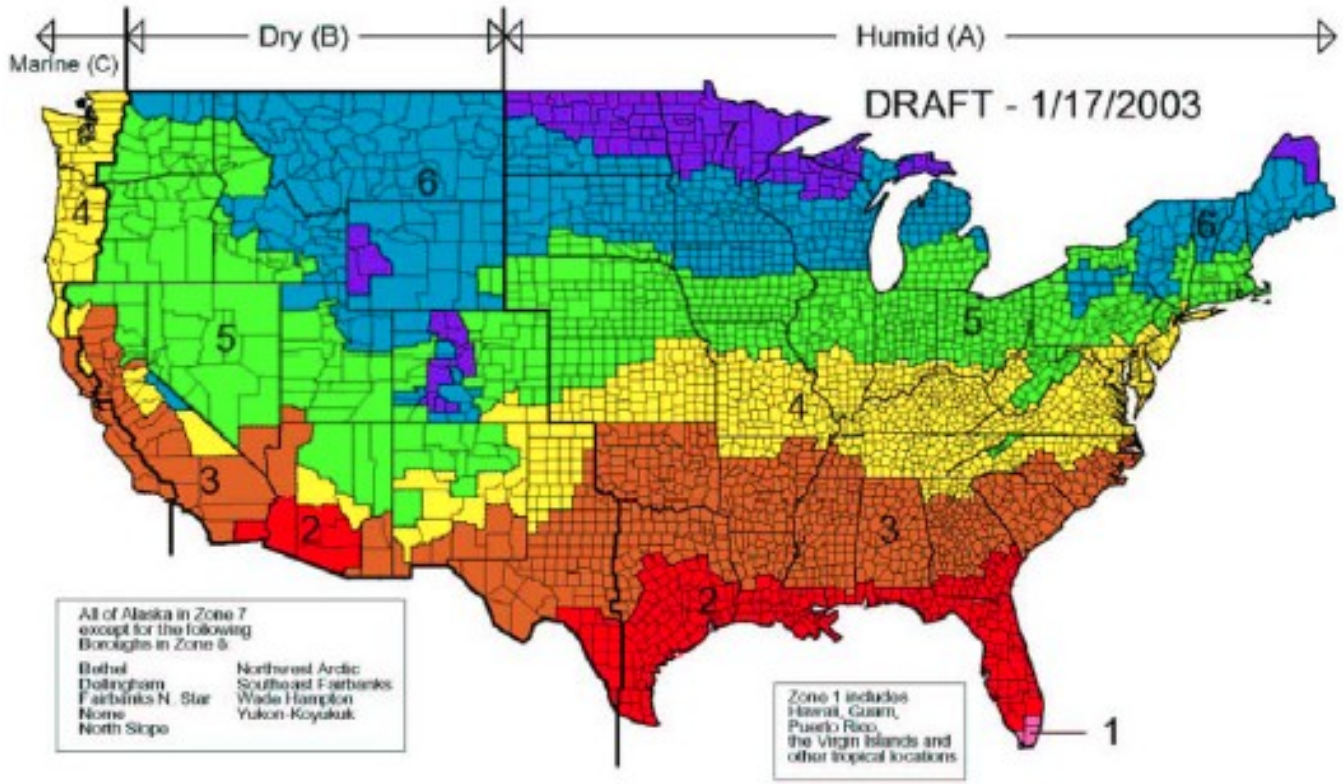
TEMF Study Approach

- Review existing standard TEMF design
- Visit representative TEMF facilities
- Develop candidate technology options
  - Must improve facility performance
  - Must be cost-effective
  - Must by standard industry practice
- ***Evaluate options (new technology screening)***
- Participate in charrette/design process for new std TEMF
- Develop “final” recommendations
- Follow thru with G4, ACSIM and Corps folks



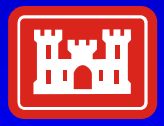
DOE U.S. Climate Zones

Figure 3-1: Climate Zone Map



Representative Cities for Climate Zones

- 1 - A - Miami, FL
- 2 - A - Houston, TX
  - B - Phoenix, AZ
- 3 - A - Memphis, TN
  - B - El Paso, TX
- 4 - A - Baltimore, MD
  - B - Albuquerque, NM
- 5 - A - Chicago, IL
  - B - Boise, ID
- 6 - A - Burlington, VT
- 7 - Duluth, MN
- 8 - Fairbanks, AK



Base Case

- 6 “bays” 20m X 10m X 10m ea
- Total volume 12,000 m**3
- Make up air at 6 air changes/hour
- Maintain 18 deg C (65 deg F) in bays
- Heated only!
- Based on exist stnd dsgn

Base case + 14 tech options in 12 locations

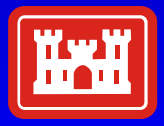
Any ?s

US Army Corps of Engineers

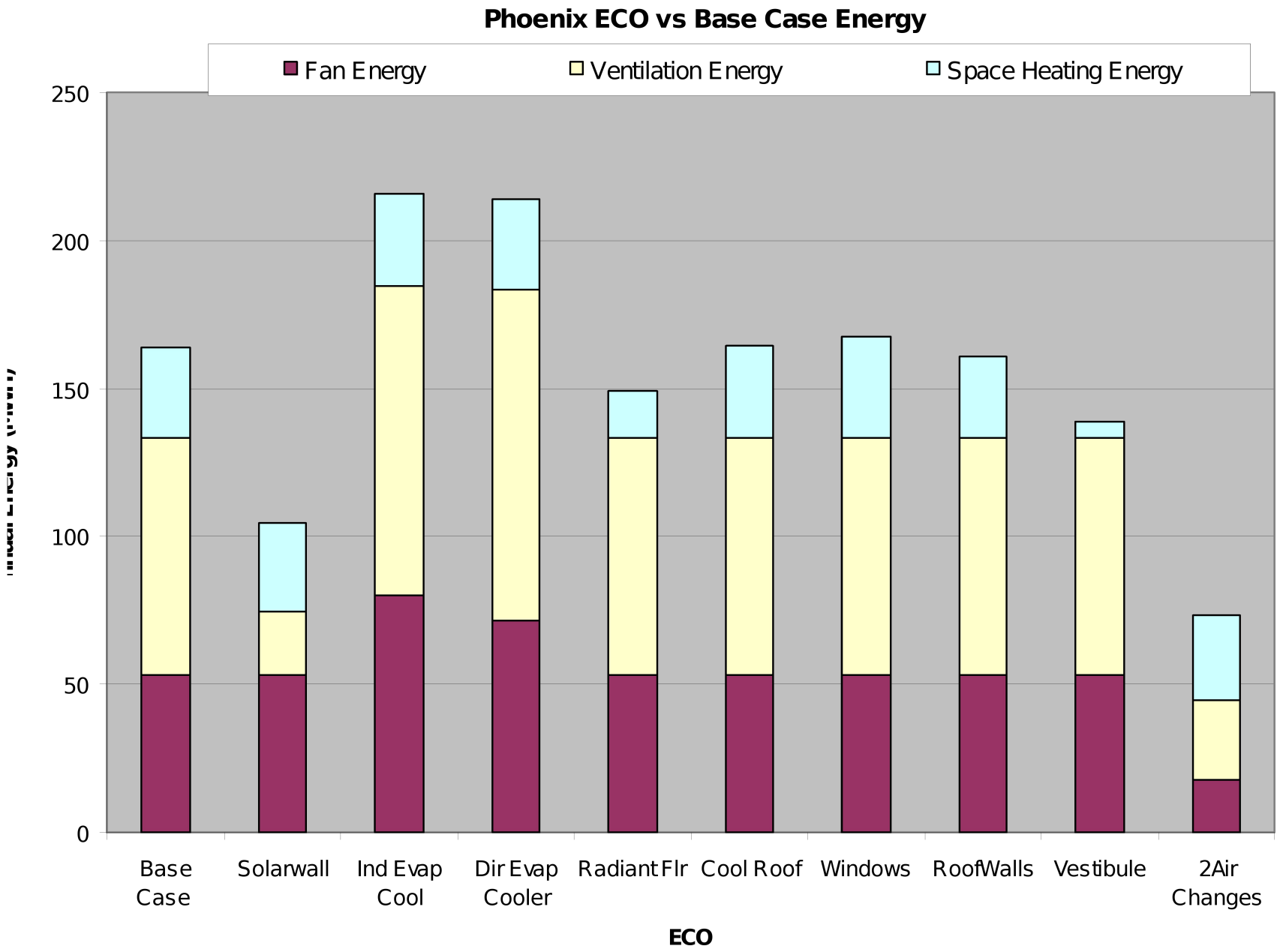
File Name	General Lights: Electricity [J](Annual)	Electricity: Building [J](Annual)	Fans: Electricity [J](Annual)	Make Up Air Heating: Energy Transfer [J](Annual)	Zone Heating: Energy Transfer [J](Annual)	Electricity: HVAC [J](Annual)	Electricity: Facility [J](Annual)
6ACH_MakeUpAir_BaseCase_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.142E+12	3.25504E+12	8.41131E+12	8.66502E+12
6ACH_MakeUpAir_BaseCase_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.29844E+11	87616971464	5.45115E+11	7.98824E+11
6ACH_MakeUpAir_BaseCase_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	26844530596	4518506278	2.27229E+11	4.80937E+11
6ACH_MakeUpAir_BaseCase_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.37689E+12	7.649E+11	2.57214E+12	2.82585E+12
6ACH_MakeUpAir_BaseCase_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.70527E+12	9.67314E+11	3.16192E+12	3.41563E+12
6ACH_MakeUpAir_BaseCase_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.27294E+12	6.52944E+11	2.33225E+12	2.58596E+12
6ACH_MakeUpAir_BaseCase_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.64932E+12	1.83683E+12	5.177E+12	5.43071E+12
6ACH_MakeUpAir_BaseCase_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	8.26438E+11	4.40149E+11	1.5997E+12	1.85341E+12
6ACH_MakeUpAir_BaseCase_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	7.42894E+11	3.3905E+11	1.39454E+12	1.64825E+12
6ACH_MakeUpAir_BaseCase_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.1399E+11	2.08189E+11	8.83691E+11	1.1374E+12
6ACH_MakeUpAir_BaseCase_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	3.42831E+11	1.54762E+11	7.45261E+11	9.9897E+11
6ACH_MakeUpAir_BaseCase_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.09272E+12	1.27773E+12	3.93733E+12	4.19104E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	64095676048	1.37999E+12	3.10028E+12	5.04218E+12	5.29589E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	64095676048	76579244782	84028582509	2.42549E+11	4.96258E+11
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	64095676048	8943818279	3945878665	78417561541	3.32126E+11
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	64095676048	4.58738E+11	7.3775E+11	1.39353E+12	1.64724E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	64095676048	5.68148E+11	9.53818E+11	1.75517E+12	2.00888E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	64095676048	4.24106E+11	6.42927E+11	1.24969E+12	1.5034E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	64095676048	8.82677E+11	1.73773E+12	2.97566E+12	3.22937E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	64095676048	2.75345E+11	4.34204E+11	8.52483E+11	1.10619E+12
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	64095676048	2.47511E+11	3.3608E+11	7.1253E+11	9.66238E+11
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	64095676048	1.37929E+11	2.00256E+11	4.39857E+11	6.93566E+11
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	64095676048	1.14227E+11	1.52318E+11	3.60256E+11	6.13965E+11
VehicleExhaustRecovery_2ACH_MakeUpAir_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	64095676048	6.97235E+11	1.24894E+12	2.22651E+12	2.48022E+12
SolarWall_6ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	3.42259E+12	3.13723E+12	7.48108E+12	7.73479E+12
SolarWall_6ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	61566089164	85276119993	3.55539E+11	6.09248E+11
SolarWall_6ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	5086403461	4255071254	2.0276E+11	4.56469E+11
SolarWall_6ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	6.91399E+11	7.36037E+11	1.77842E+12	2.03213E+12
SolarWall_6ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.07647E+12	9.46116E+11	2.4397E+12	2.69341E+12
SolarWall_6ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	6.65744E+11	6.34122E+11	1.63668E+12	1.89039E+12
SolarWall_6ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.75349E+12	1.76153E+12	4.09796E+12	4.35167E+12
SolarWall_6ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.5067E+11	4.29722E+11	9.48372E+11	1.20208E+12
SolarWall_6ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	3.12192E+11	3.32082E+11	9.08242E+11	1.16195E+12
SolarWall_6ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.1076E+11	2.02473E+11	5.40417E+11	7.94126E+11
SolarWall_6ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.62902E+11	1.52186E+11	5.42479E+11	7.96188E+11
SolarWall_6ACH_MakeUpAir_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.32531E+12	1.24495E+12	3.04823E+12	3.30194E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	4.08233E+12	3.23848E+12	8.42753E+12	8.68124E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	3.00557E+11	90000900979	8.22789E+11	1.0765E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	28774365988	4721078745	4.56238E+11	7.09947E+11
EvapCoolerIndirect_6ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	1.33989E+12	7.60099E+11	2.65605E+12	2.90976E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	1.67671E+12	9.60909E+11	3.25917E+12	3.51288E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	1.243E+12	6.47965E+11	2.43581E+12	2.68951E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	2.59528E+12	1.82342E+12	5.21056E+12	5.46427E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	8.64765E+11	4.41306E+11	1.79615E+12	2.04986E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	7.41667E+11	3.39679E+11	1.55901E+12	1.81272E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	5.43302E+11	2.17444E+11	1.21504E+12	1.46875E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	3.37209E+11	1.55874E+11	9.30811E+11	1.18452E+12
EvapCoolerIndirect_6ACH_MakeUpAir_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	2.88571E+11	2.04667E+12	1.269E+12	3.99639E+12	4.2501E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	4.10205E+12	3.24438E+12	8.41926E+12	8.67297E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	3.22552E+11	88814754903	7.14606E+11	9.68315E+11
EvapCoolerDirect_6ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	28698791797	4706833180	2.95005E+11	5.48713E+11
EvapCoolerDirect_6ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	1.35109E+12	7.64266E+11	2.60726E+12	2.86097E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	1.67815E+12	9.63649E+11	3.19227E+12	3.44598E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	1.24998E+12	6.50047E+11	2.36814E+12	2.62185E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	2.61325E+12	1.82854E+12	5.19196E+12	5.44566E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	8.4072E+11	4.41632E+11	1.68192E+12	1.93563E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	7.35123E+11	3.39693E+11	1.45147E+12	1.70518E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	5.138E+11	2.14546E+11	1.06659E+12	1.3203E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	3.37071E+11	1.56123E+11	8.0549E+11	1.0592E+12
EvapCoolerDirect_6ACH_MakeUpAir_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	2.56508E+11	2.06184E+12	1.2734E+12	3.96259E+12	4.2163E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.14104E+12	2.86561E+12	7.65914E+12	7.91285E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.29836E+11	45688492306	4.93442E+11	7.47151E+11
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	26844530596	7289471626	2.29497E+11	4.83206E+11
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.37689E+12	4.72787E+11	2.19504E+12	2.44875E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.70527E+12	6.54573E+11	2.7417E+12	2.99541E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.27294E+12	4.59443E+11	2.0662E+12	2.31991E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.64926E+12	1.51344E+12	4.64944E+12	4.90315E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	8.26438E+11	1.83238E+11	1.29388E+12	1.54759E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	7.42894E+11	2.59099E+11	1.27692E+12	1.53063E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.1399E+11	1.72659E+11	8.25029E+11	1.07874E+12
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	3.42802E+11	1.2715E+11	7.00422E+11	9.54131E+11
RadiantLoIntensityFlr_6ACH_MakeUpAir_USA_VT_Burlington_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.09272E+12	1.04114E+12	3.55876E+12	3.81247E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_AK_Fairbanks_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.142E+12	3.26238E+12	8.41947E+12	8.67318E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_AZ_Phoenix_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.29845E+11	90153993604	5.47935E+11	8.01644E+11
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_FL_Miami_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	26844530596	4680449160	2.27408E+11	4.81117E+11
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_ID_Boise_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.37689E+12	7.78766E+11	2.58755E+12	2.84126E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_IL_Chicago_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.70527E+12	9.79806E+11	3.1758E+12	3.42951E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_MD_Baltimore_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	1.27294E+12	6.62532E+11	2.3429E+12	2.59661E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_MN_Duluth_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	2.64932E+12	1.85941E+12	5.20208E+12	5.45579E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_NM_Albuquerque_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	8.26438E+11	4.51323E+11	1.61211E+12	1.86582E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_TN_Memphis_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	7.42894E+11	3.46086E+11	1.40236E+12	1.65607E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_TX_El.Paso_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	4.1399E+11	2.14539E+11	8.90746E+11	1.14445E+12
CoolRoofsHeatingOnly_6ACH_MakeUpAir_USA_TX_Houston_TMY2	1.38363E+11	2.53709E+11	1.92381E+11	3.42832E+11	1.58472E+11	7.49385E+11	1.00309E+12

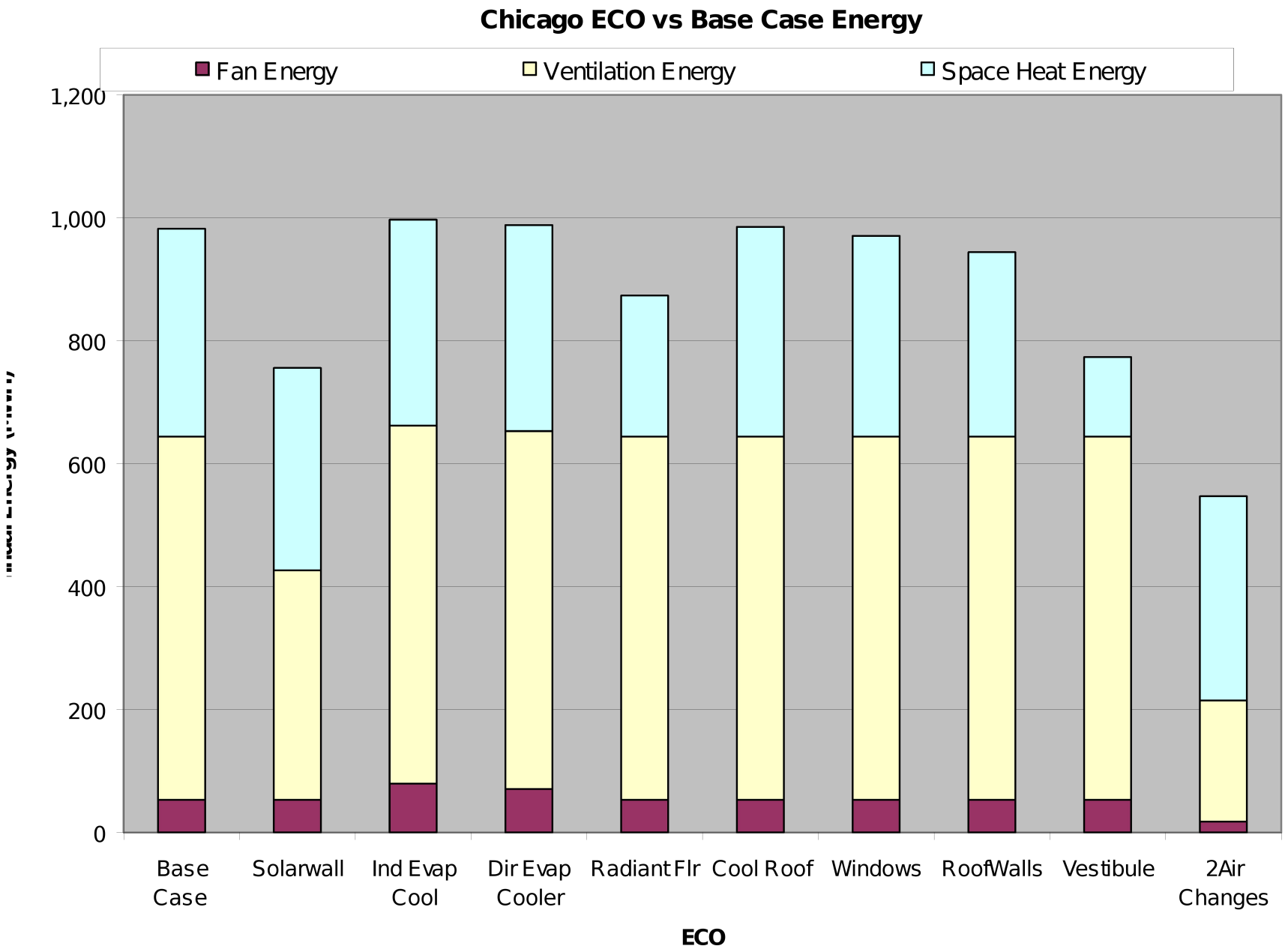
Details of Technology Screening Process and Selected Results

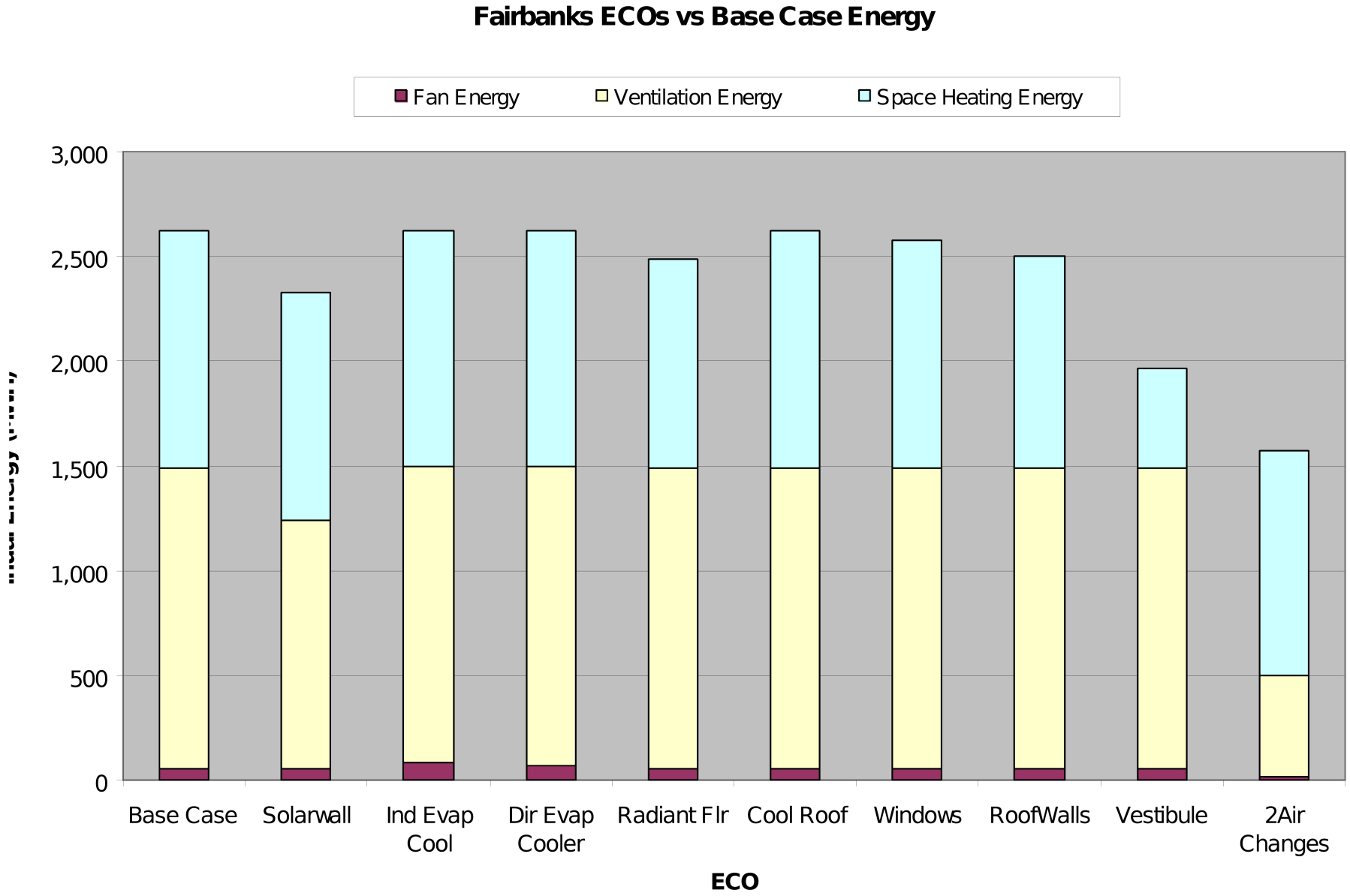
- First, for each location, we compared individual technology options to the base case to determine energy savings and comfort improvement.
- Next, for each location, we grouped favorable low/no first cost options into a “Combined Option” and determined energy savings and comfort improvement compared to the base case.
- Finally, we studied some higher first cost options added to the “combined option” for each location.



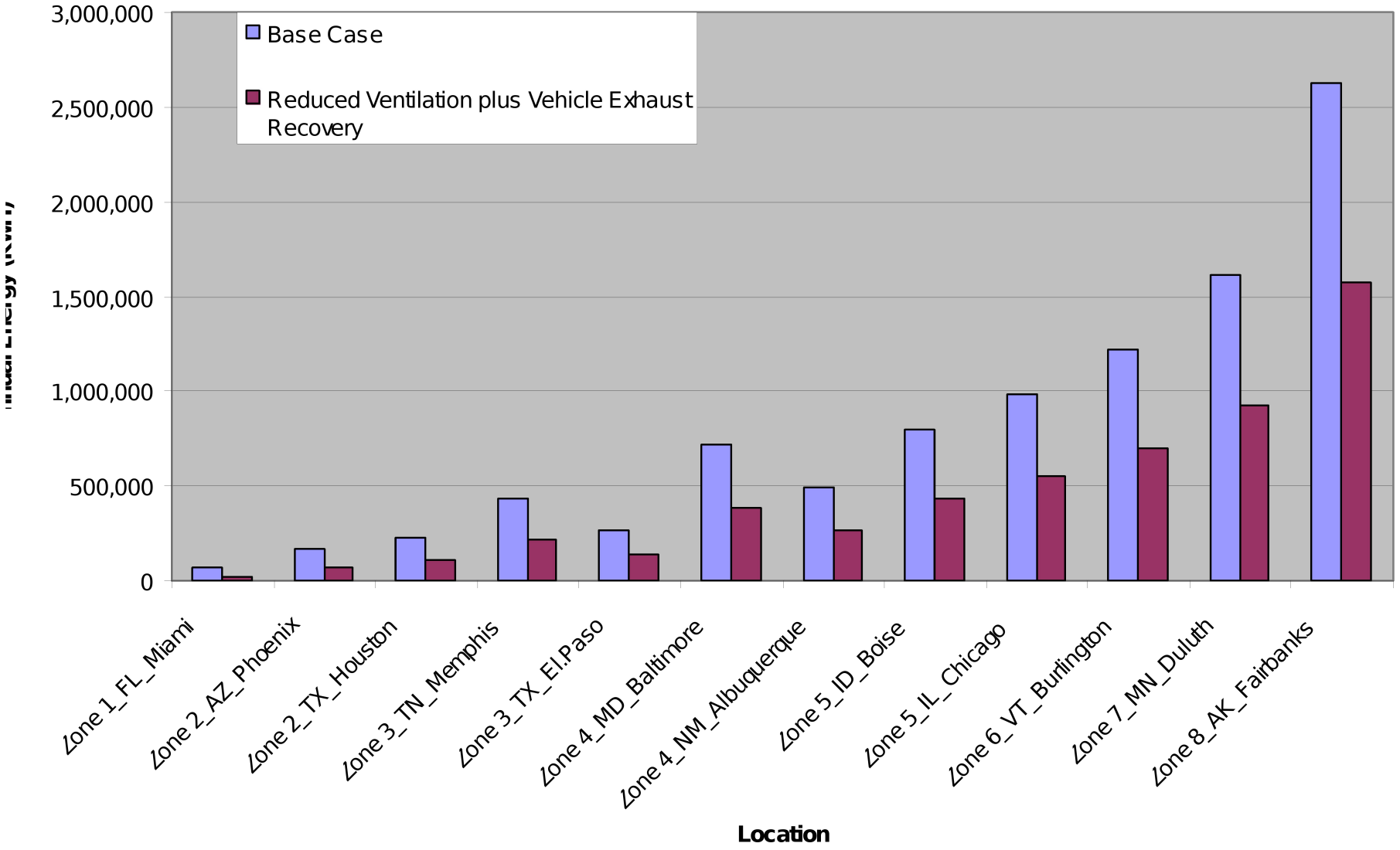
Individual Technologies Compared to Base Case


Phoenix ECO vs Base Case Energy
Fan Energy
Ventilation Energy
Space Heating Energy
250
200
150
100
50
0
Base Case
Solarwall
Ind Evap Cool
Dir Evap Cooler
Radiant Flr
Cool Roof
Windows
RoofWalls
Vestibule
2Air Changes
ECO

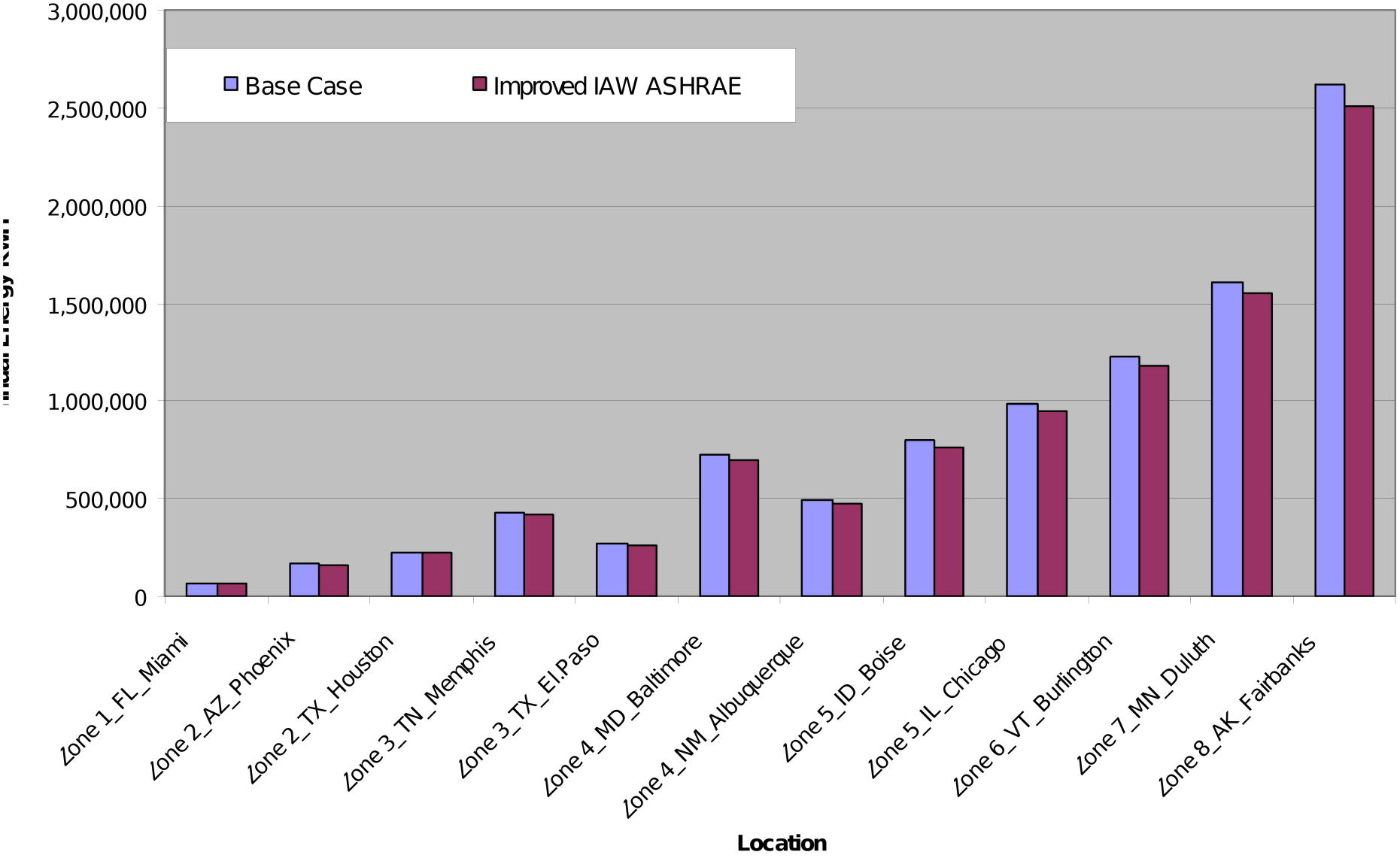

Chicago ECO vs Base Case Energy
Fan Energy
Ventilation Energy
Space Heat Energy
1,200
1,000
800
600
400
200
0
Base Case
Solarwall
Ind Evap Cool
Dir Evap Cooler
Radiant Flr
Cool Roof
Windows
RoofWalls
Vestibule
2Air Changes
ECO


Fairbanks ECOs vs Base Case Energy
Fan Energy
Ventilation Energy
Space Heating Energy
3,000
2,500
2,000
1,500
1,000
500
0
Base Case
Solarwall
Ind Evap Cool
Dir Evap Cooler
Radiant Flr
Cool Roof
Windows
RoofWalls
Vestibule
2Air Changes
ECO

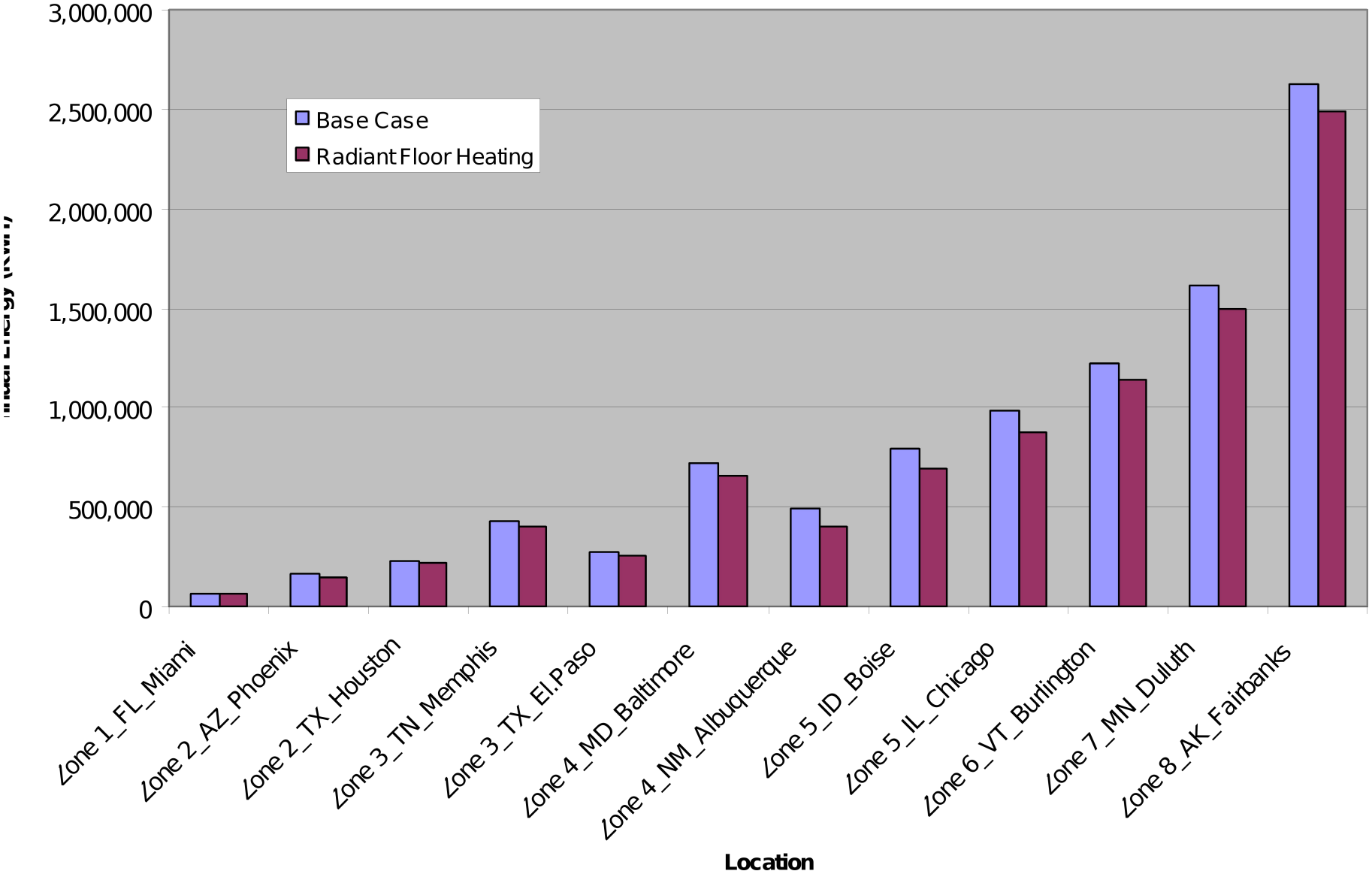
Reduced Ventilation vs Base Case Energy



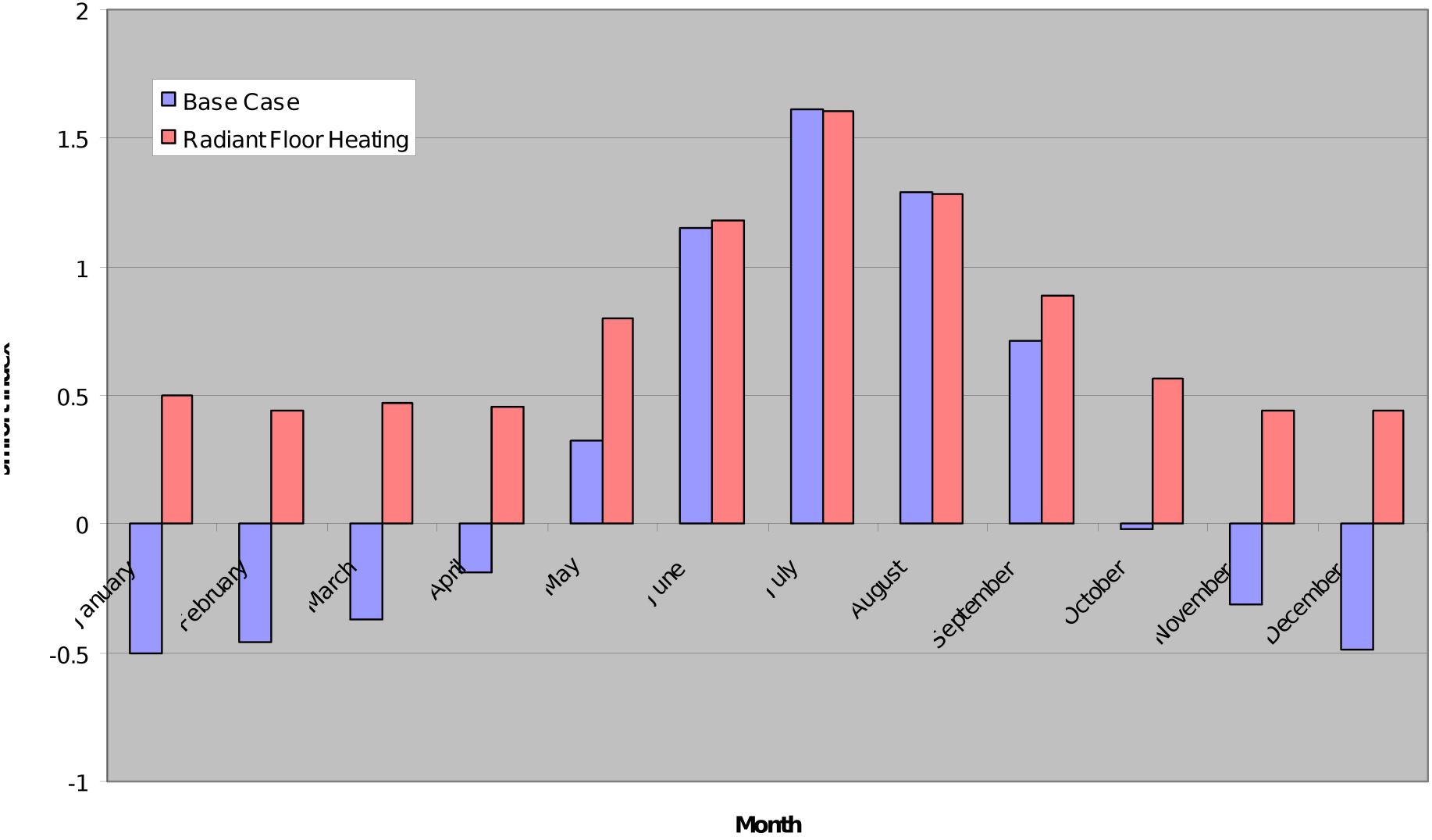
Walls/Roof IAW ASHRAE vs Base Case



Radiant Floor Heating Vs Base Case

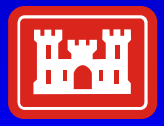


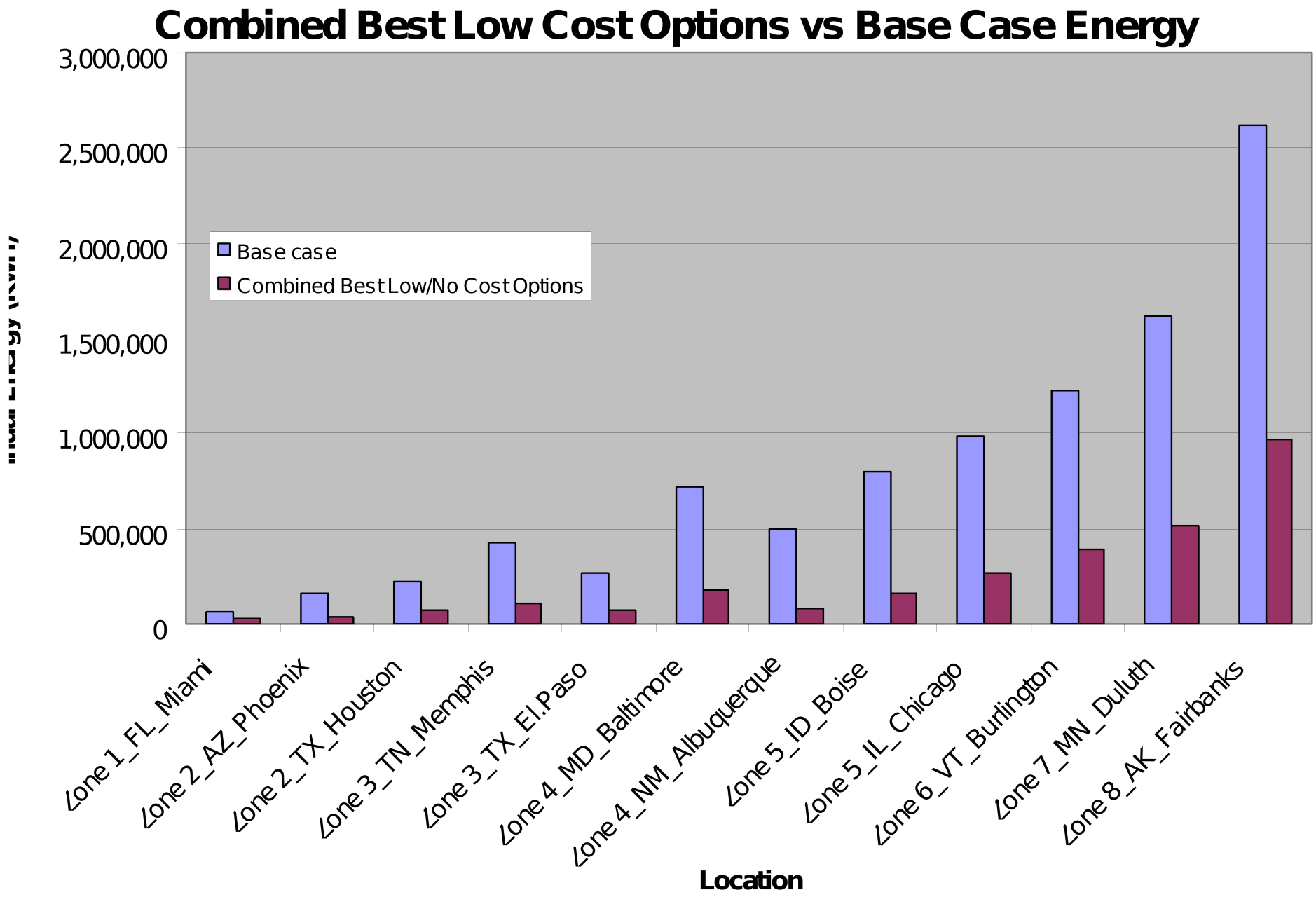
Fanger Comfort Index for Chicago Radiant Floor Heating vs Base Case



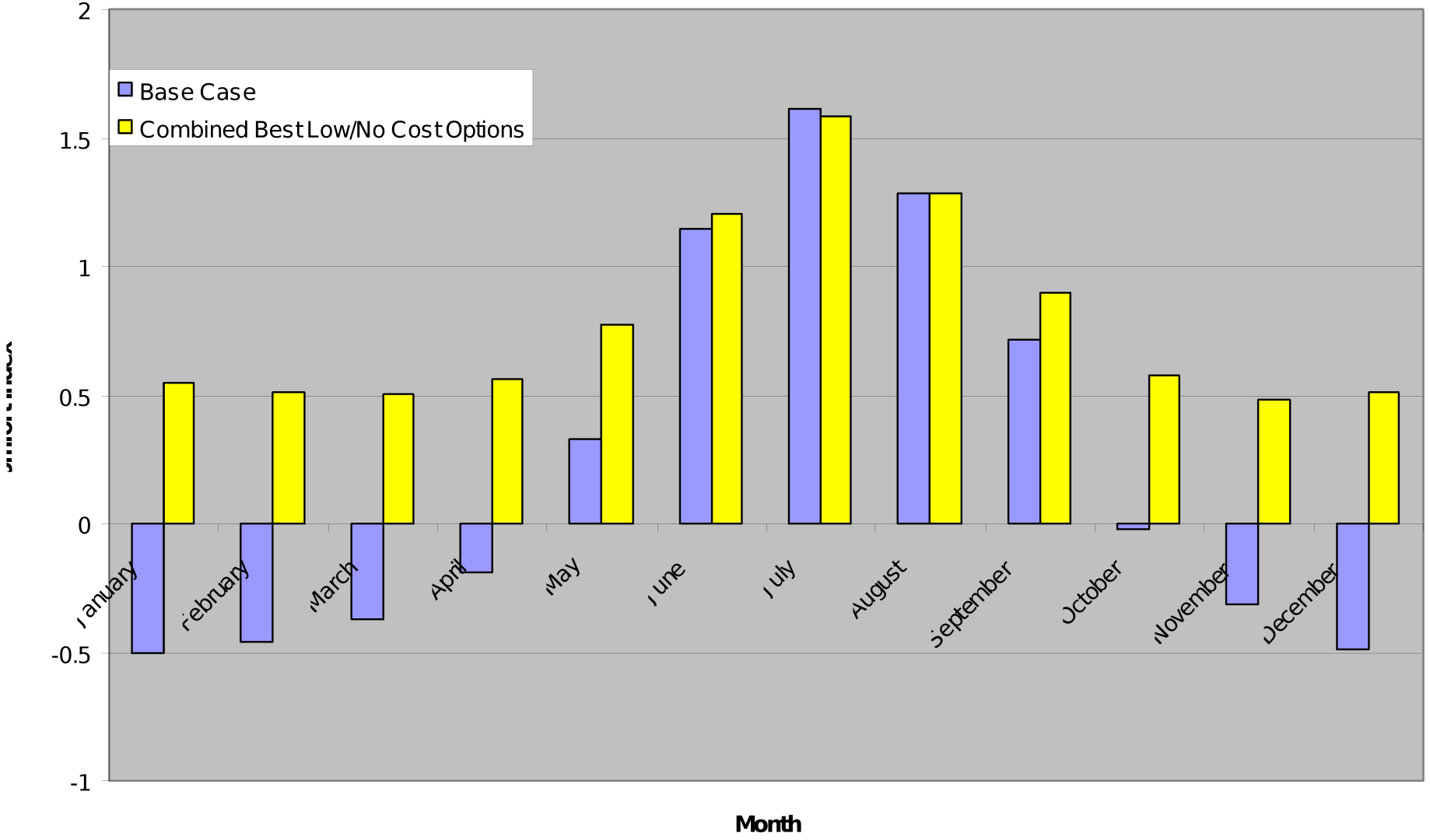
Combined Technologies vs Base Case

- Technologies which improved energy performance and/or comfort AND were low/no cost
  - Reduced ventilation plus vehicle exhaust recovery
  - Solar Wall for ventilation air pre-heat
  - Walls, roofs, windows IAW ASHRAE
  - Radiant Floor Hydronic Heating

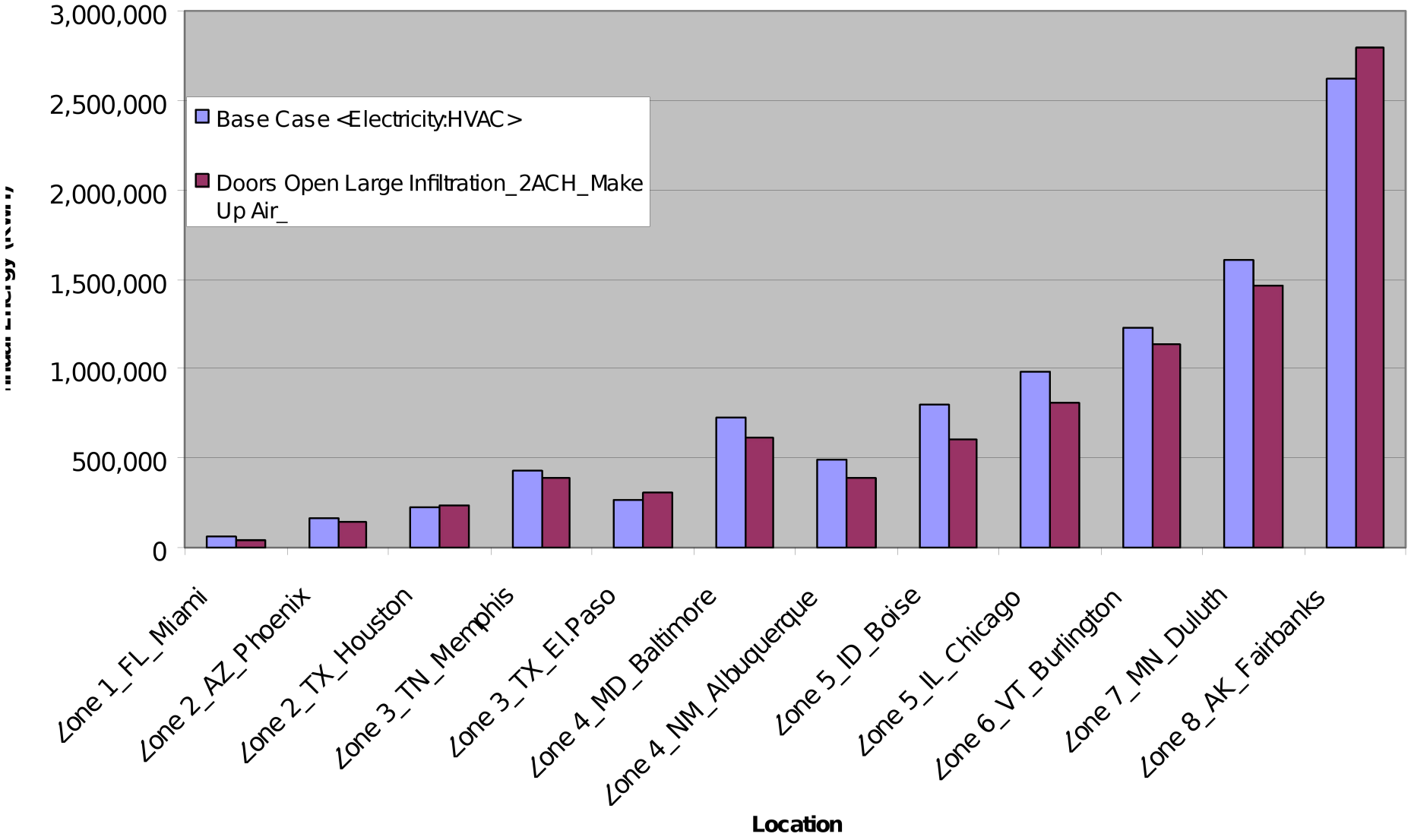



Combined Best Low Cost Options vs Base Case Energy
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
Base case
Combined Best Low/No Cost Options
Zone 1_FL_Miami
Zone 2_AZ_Phoenix
Zone 2_TX_Houston
Zone 3_TN_Memphis
Zone 3_TX_El Paso
Zone 4_MD_Baltimore
Zone 4_NM_Albuquerque
Zone 5_ID_Boise
Zone 5_IL_Chicago
Zone 6_VT_Burlington
Zone 7_MN_Duluth
Zone 8_AK_Fairbanks
Location

Fanger Comfort Index for Chicago



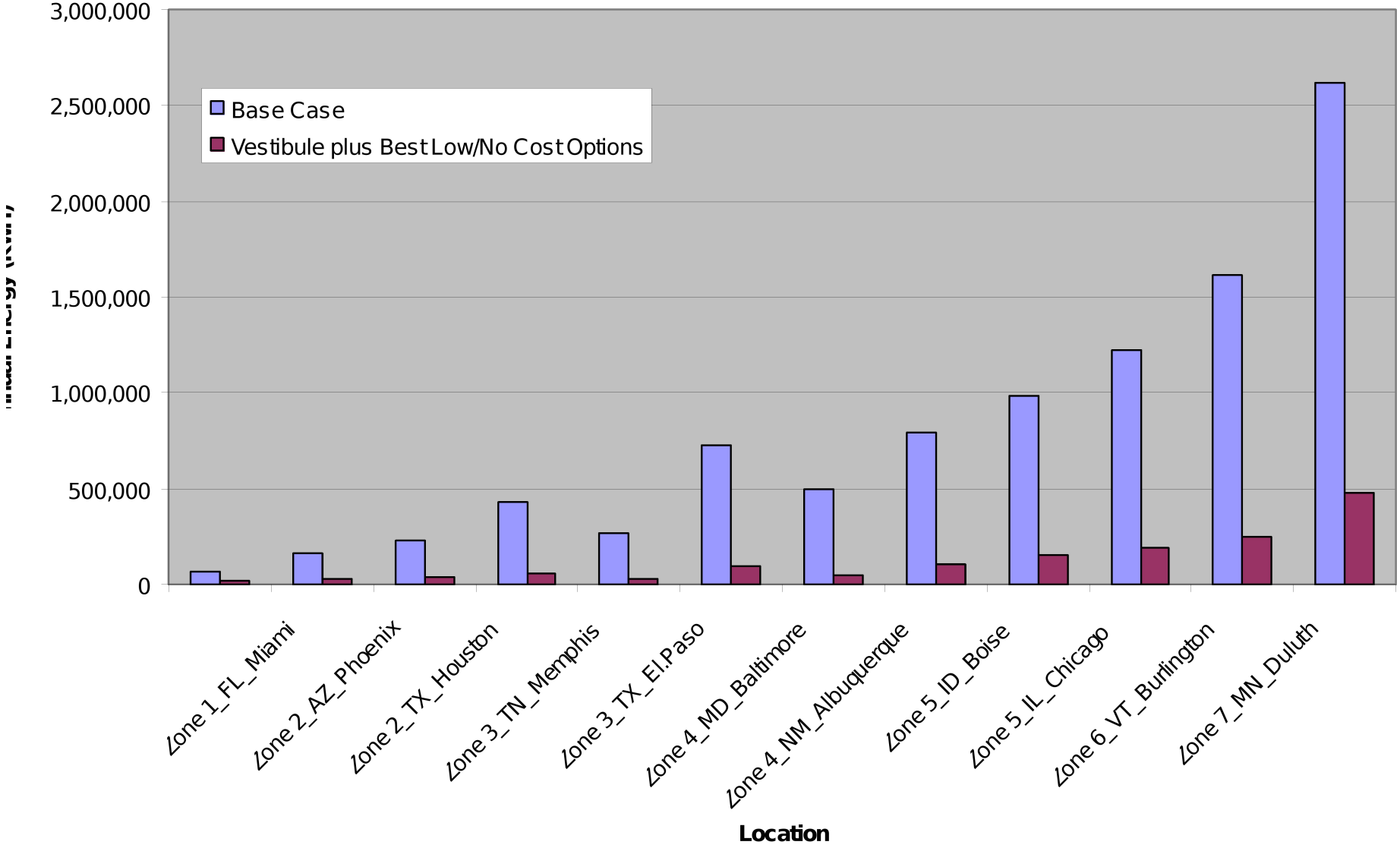
Best Options with Doors Open vs Base Case with Doors Closed



High First Cost Options Added

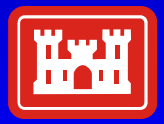
- Direct Evaporative Cooling (to be done)
- Indirect Evaporative Cooling (to be done)
- Entry and Exit Vestibule

Vestibules plus Best Options vs Base Case Energy



Summary for Chicago

Case	Annual HVAC Energy Consum (MwH)	Annual HVAC Energy Cost ($)	Annual HVAC Energy Savings ($)	First Cost to Implement ($)	Payback (Yrs)
Base	981	$37,300			
Best Options	269	$10,400	$26,900	$0.0	Instant
Vest (12)+ Bst Options	150	$ 6351	$30,949	$240,000	7.75 yrs



Conclusions

- These technologies should be added to TEMF standard design in all climates
  - Reduced Ventilation with Robust Vehicle Exhaust Recovery
  - Solar Wall for Ventilation Air Pre-Heat
  - Envelope IAW new ASHRAE guide
  - Radiant Floor Hydronic Heating
  - Cool Roofs

Conclusions (cont)

- Vestibules should be added in northern climates (exact range still being determined)
- Evaporative cooling should be added in southern climates (exact range still being determined)
- Don’t leave the doors open on TEMF!!
- Technology screening works!!